WIND RIPPLES IN LOW DENSITY ATMOSPHERES

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The *dynamic pressure* of a fluid, $1/2\ \rho\ U^2$ (ρ = fluid density, U = fluid velocity) is a primary factor controlling the motion of particles transported in either a liquid or a gas. This quantity is usually varied in experiments by making changes in U. In the Martian Surface Wind Tunnel[1] (MARSWIT), we have examined the effect of varying ρ on particle transport by conducting tests at atmospheric pressures between 1 and 0.004 bar. This study specifically concerns the effect of varying ρ on the character of wind ripples, and elicits information concerning generalized ripple models [2,3] as well as specific geological circumstances for ripple formation such as those prevailing on Mars (atm. press. = 0.0075 bar). In all the MARSWIT experiments, run times were sufficient to procure ripple equilibrium: ripple height and wavelength λ were stable with time. Tests were conducted primarily with 95 μm quartz sand, and for each atmospheric pressure chosen, tests were conducted at two (freestream) wind speeds: 1.1 U_{*t} and 1.5 U_{*t}, where U_{*t} is saltation threshold.

Figure 1 shows the relationship between saltation threshold and atmospheric pressure to be exponential. There is little variation in U_{*t} down to ~0.25 bar, but below this pressure, U_{*t} rises very sharply. Ripples appeared at all pressures tested for both wind speeds. Wavelength data is summarized in Figure 2 from which it is apparent that there are three distinct ripple trends. Trends A and B represent relatively large "ballistic" ripples that show a distinct increase in λ with decreasing atmospheric pressure (for threshold-normalized wind speeds). These are well defined in Figure 3 (oblique photos of the MARSWIT test beds) for 1.5 U_{*t}. The amplitude of these ripples dimishes with decreasing pressure until they are no more than narrow ridges at 0.125 bar and, thereafter, the features disappear. Trend D represents small structures (probably aerodynamic in origin) superimposed on the larger ripples, They were best developed at 1.1 U_{*t} (see Fig. 3) and their wavelengths are more or less independent of atmospheric pressure. Trend C represents laterally discontinuous ripples formed from the coarser fraction of the sand (naturally sorted on the bed by the wind at low pressures), but their relationship to wind speed and pressure is not very clear.

Data analysis is in a preliminary stage, but the MARSWIT data suggests: 1) ballistic ripple wavelength is not at variance with model [2,3] predictions, 2) an atmospheric pressure of ~0.2 bar could represent a discontinuity in ripple behavior, 3) ripple formation on Mars may not be readily predicted by extrapolation of terrestrial observations.

References: 1) Greeley, R., Iversen, J.D., Pollack,. J.B., Udovich, N., White, B.R. (1974), Proc. Roy. Soc. A341, 331-336. 2) Bagnold, R.A. (1941), The Physics of Blown Sand and Desert Dunes, Chapman & Hall, 265, p. 3) Sharp, R.P. (1963), J. Geol., 71, 517-636.

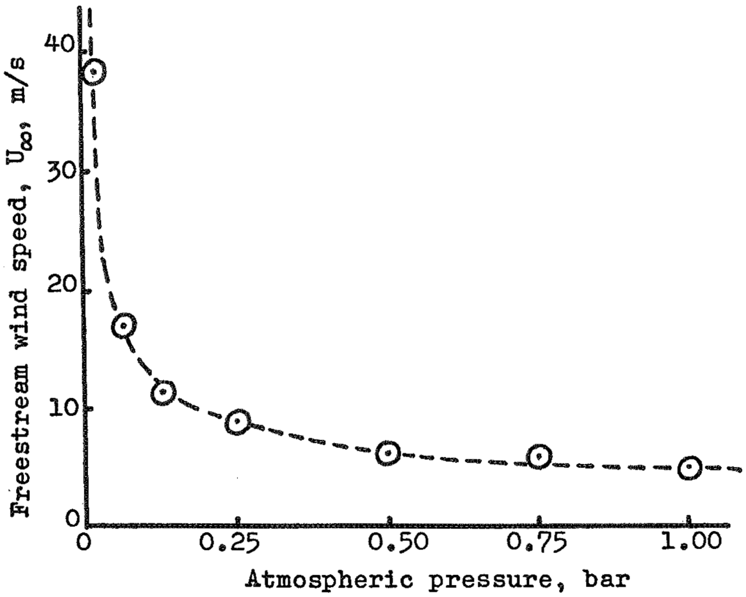

FIGURE 1. Threshold wind speed as a function of atmospheric pressure for 95 µm quartz particles

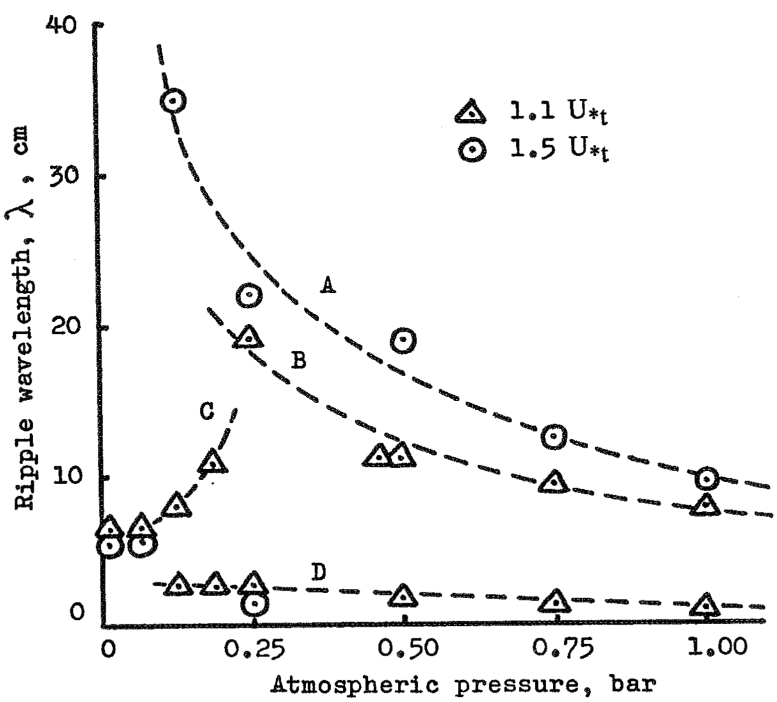

FIGURE 2. Ripple wavelength as a function of atmospheric pressure and wind speed for 95 µm quartz particles

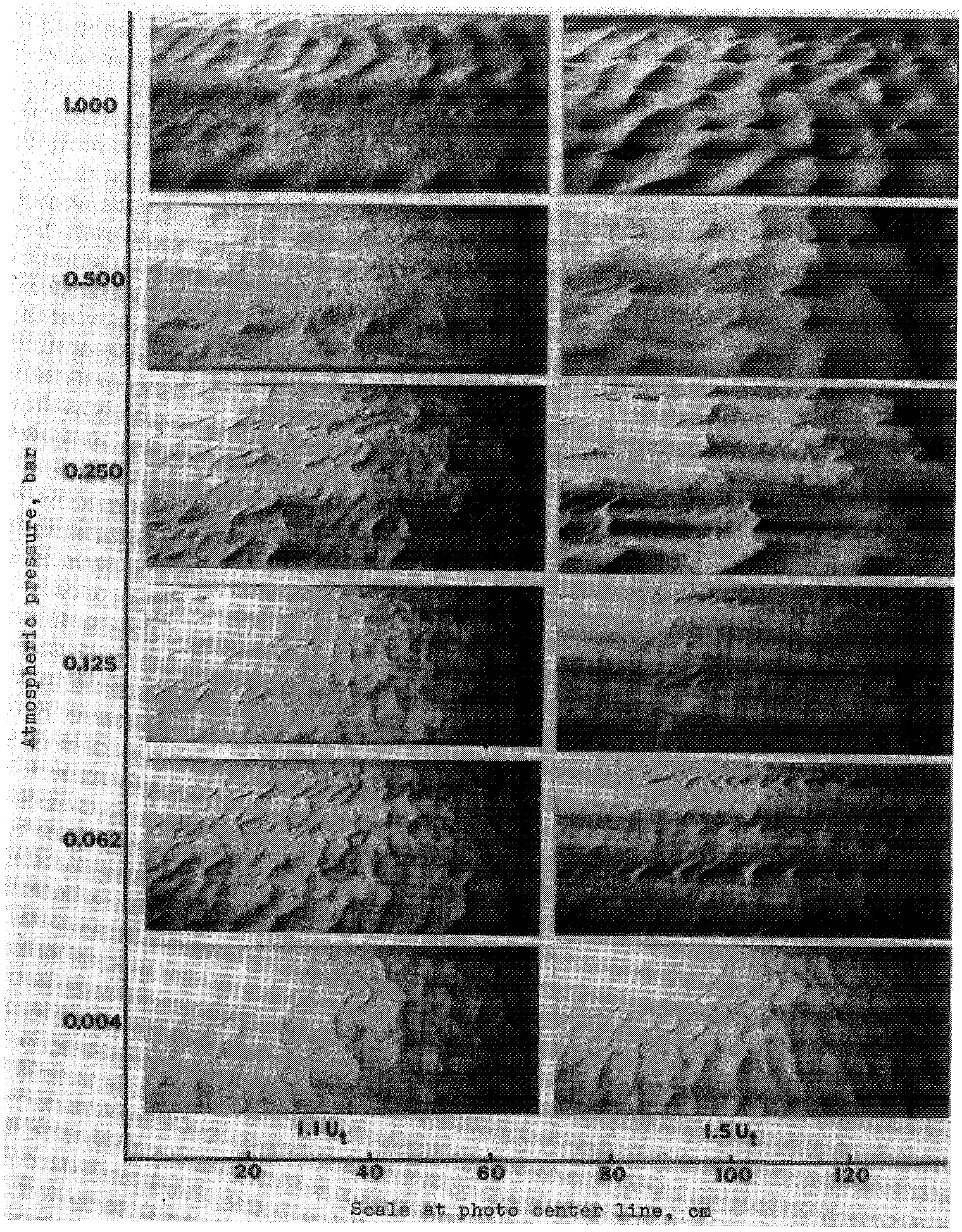

FIGURE 3. Rippled sand surfaces in MARSWIT produced over a range of atmospheric pressures at two wind speeds (oblique photographs). Wind direction is from the left; illumination from upper left.